July-August 1951

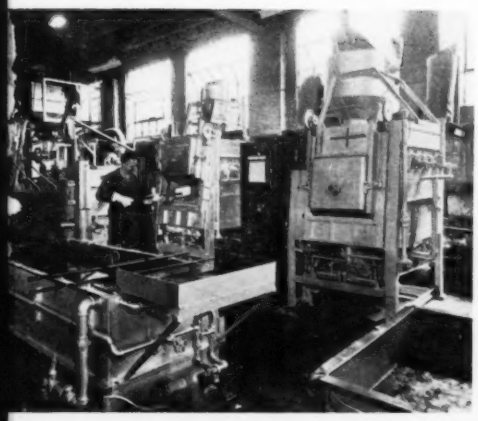
METAL TREATING

MASTER CRAFTSMEN
METAL TREATING INSTITUTE

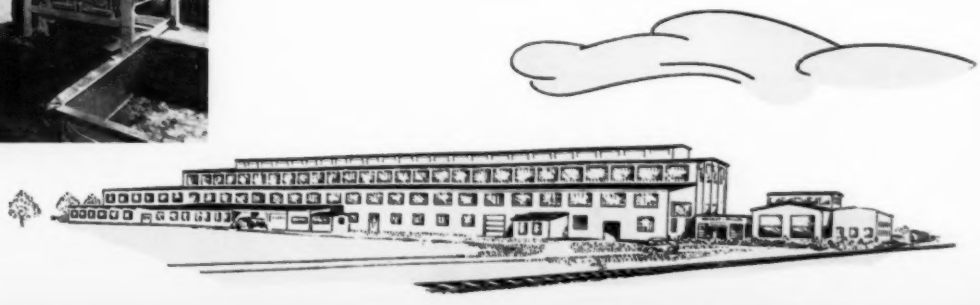
JOURNAL OF THE METAL TREATING INSTITUTE

National Trade Association of

COMMERCIAL HEAT TREATERS

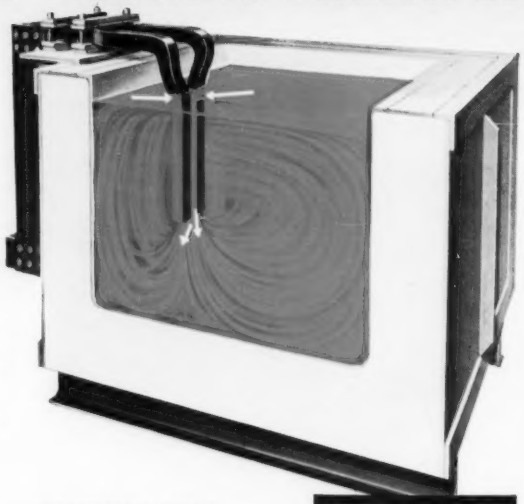


Benedict-Miller, Inc. (B-M Heat Treating Co.), Lyndhurst, New Jersey, an MTI member, provide an unusual combination of facilities to industry. In this new plant, covering 8½ acres of ground and 100,000 sq. ft. of warehouse space, they offer both complete commercial heat treating facilities (left) and steel warehousing service.

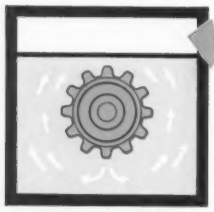


THE MOST EFFICIENT HEAT TREATING PRINCIPLE

...for CARBURIZING • CYANIDE HARDENING • NEUTRAL HARDENING • ANNEALING OR HARDENING STAINLESS STEEL • BRAZING • HARDENING HIGHSPEED STEEL • AUSTEMPERING • MARTEMPERING • PROCESS ANNEALING • CYCLIC ANNEALING • DRAWING (TEMPERING) • SOLUTION HEAT TREATMENT • DESCALING • DESANDING • CLEANING

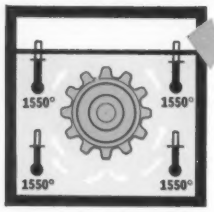


In the Ajax Electric Salt Bath, utilizing immersed electrodes, all heat is generated within the bath itself—the liquid salt acting as a "resistor". Electrodynamic forces produce vigorous circulation throughout the bath, in the *downward* motion indicated. This is precisely opposite to the *upward* thermal flow—dependent on a temperature difference in a bath—which exists in other salt bath furnaces. Only Ajax offers electrodynamic circulation!



RAPID HEATING BY CONDUCTION

The rate of heating depends only on the heat conductivity of the work itself. Thus, the Ajax Salt Bath Furnace heats work 4 to 6 times faster than a radiation type or forced convection furnace.



UNIFORM HEATING

The liquid salt completely surrounds the work and the automatic stirring action transmits uniform heat to all surfaces simultaneously. No other method delivers such heating uniformity—within 5° F. or *less* at any part of the bath.

NO ATMOSPHERE PROBLEMS

The Ajax Electric Salt Bath Furnace eliminates *all* atmosphere control problems. Scaling, oxidation and decarb are avoided. First cost of gas generating equipment as well as its operating expense are eliminated.

AUTOMATIC PREHEATING

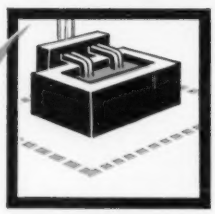
When a cold piece of metal is immersed, a "cocoon" of frozen salt forms around it instantly. This layer serves as a temporary insulator, preventing temperature shock and too sudden heating. The frozen salt melts in a minute or less and the work then heats rapidly to bath temperature.

BUOYANCY THAT MINIMIZES DISTORTION

Although the work sinks readily into the liquid salt, the bath nevertheless supports it to a marked degree. In effect, the work weighs appreciably less when immersed and this tends to prevent distortion and warpage.

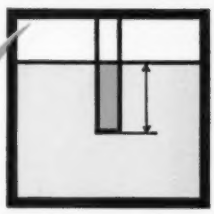
MORE PRODUCTION IN LESS FLOOR SPACE

Because an Ajax furnace heats work so much faster—and because it eliminates the need for atmosphere generators and similar bulky auxiliary equipment, a proportionately smaller amount of floor space is required to handle a given volume of work.



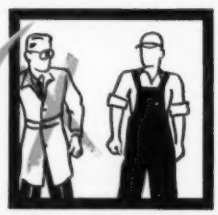
SELECTIVE HEATING

Because of its rapid heating rate, only that portion of the work immersed in the bath is heated. Just dip and treat *any desired portion* of any metal part or assembly.



NO SKILLED LABOR

Operation is so entirely automatic, so closely controlled by the Ajax furnace itself, that even an unskilled operator can handle full production.



72 pages of factual heat treating data! Write for Catalog 116 on your company stationery.

AJAX ELECTRIC SALT BATH FURNACES

HULTGREN

AJAX ELECTRIC COMPANY, INC. 940 Frankford Ave., Philadelphia 23, Pa.

The World's Largest Manufacturer of Electric Heat Treating Furnaces Exclusively

Editorial...

A SUGGESTION FOR ALLEVIATING THE ALLOY SHORTAGE

Again, the defense emergency has created a shortage of alloying elements required to produce so many vital parts and products. Better guns, tanks, engines and aircraft require steels of greater strength, resistance to shock, and in the case of jet engines to higher and higher temperatures.

All this has put an unprecedented and apparently unforeseen demand upon our supply of the vital alloying elements nickel, chromium, molybdenum, manganese, tungsten, vanadium, and others.

In an attempt to cope with this shortage, the Government, under the Controlled Materials Plan, is putting forth strenuous efforts to limit the use of these indispensable and hard-to-get elements to only the most essential requirements.

As in World War II, many manufacturers must now use the so-called "National Emergency" steels, in which a minimum of alloying elements are combined in proportions intended to provide desired physical properties in response to heat treatment. Fortunately, we have the recent metallurgical advance resulting from the use of boron, very small quantities of which greatly enhance the response of steels to heat treatment and give better combinations of strength and ductility.

Thoughtful consideration of the problems, created by alloy shortages, suggests another way in which alloying elements can be saved and the preparedness program expedited without unnecessary sacrifice in the performance qualities of steels employed in highly engineered structures.

In the specification of mechanical property requirements for engineering steels it has been customary to demand rather generous factors of elongation and reduction of area combined with a specified minimum tensile strength and yield strength. Generally with the leaner (less alloy) NE steels the strength value and metallurgical hardness, can be obtained without too much trouble but there is a tendency for ductility values to be lower than average specifications demand. This often results in rejection.

However, it is often difficult to show that a somewhat lower elongation or reduction of area value at a given strength will result in any appreciable lowering of the performance of a particular article in service. These values have been set high in many specifications simply because they are readily obtainable with the richer alloys, and not because of any practical

(Continued on page 13)

METAL TREATING

Official Journal of the Metal Treating Institute

CONTENTS

Vol. II JULY-AUGUST 1951 No. 4

FEATURES

DEPARTMENTS

C. E. Herington
Editor

C. R. Smith
Advertising and Production Manager

Horace C. Knerr
Chairman, Publication Committee

Published by the Metal Treating Institute, 271 North Avenue, New Rochelle, N. Y. Copyright 1951 by the Metal Treating Institute.

Distortion of Tool Steels in Heat Treatment

By J. Y. Riedel, *Tool Steel Engineer*
Bethlehem Steel Company
Bethlehem, Pa.

Introduction

Increased emphasis is being placed upon the close control of dimensions of manufactured parts in order to decrease production costs. The greater precision of dimensions can only be obtained by more precise tooling: consequently greater precision is being demanded from those concerned with the production of tools. The heat treatment operation used to harden tools is the most vital stage in the production of tools. Therefore, the heat treater is being asked to closely control distortion of tools in the heat treatment operations.

All too often tools are made up from so-called non-deforming steels and are finished to the final desired dimensions. Then the tools are given to the heat treater for hardening, with instructions to "avoid any distortion." Unfortunately the fallacies in this procedure are:

1. There are no non-deforming steels in the absolute sense of the word. When hardened, all tool steels undergo a volume change, which must produce some dimensional change.
2. No matter how carefully the heat treatment operation is performed, it is impossible to avoid this volume change. Thus, the hardening operation always produces some change of tool dimensions.
3. The most important single factor which determines the extent of distortion which occurs in the hardening operation is the size and shape of the tool itself. The practical control of distortion of tools must begin with the selection of the tool dimensions and allowances should be made for anticipated changes which will occur when the tools are hardened.

Components of Distortion

The term distortion, as applied to tool steel, is used to describe a change in shape or size of a tool as a result of heat treatment operations used to harden the tool. Distortion may be considered as being made up of two components, namely,

1. Warpage, which is change in shape with no change in volume of the tool.
2. Growth (or shrinkage), which is an increase (or decrease) of external dimensions resulting from the volume changes which occur as a result of the hardening operation.

The warpage factor is usually associated with the geometrical shape of the tools and with thermal stresses produced by non-uniformity of heating or cooling operations. It is practically independent of the composition of the steels used for tool steel purposes. Warpage can also occur from "sagging" of tools if they are inadequately supported when they are being heated for hardening.

Growth (or shrinkage), which occurs as a result of volume changes resulting from the hardening operation, is often called inherent distortion. The inherent distortion is a characteristic of each grade or composition of steel and varies considerably with the composition. The inherent distortion is a constant factor only when the heat treatment operations are specifically defined; variations in heat treatment can produce enormous variations in so-called inherent distortion of a given grade of steel.

Following are some typical approximate inherent distortion "factors" which are commonly used in connection with hardening of tool steel:

a. Carbon tool steel—.002"/.004" per inch (plus)
b. Mn oil hardening steel—.0015" per inch (plus)
c. Air hardening steel (5% Cr)—.001" per inch (plus)
d. High-carbon high-chromium steel—.0005" per inch (plus or minus)

These "factors" cannot ordinarily be used to predict distortion with any degree of accuracy, except in spherical objects, because of the fact that the geometry and size of the test specimens used to develop these "factors" influence the results obtained. A more precise method of studying inherent distortion characteristics is to measure specific gravity, as pointed out by Scott (1), before and after the hardening operations. From this data, changes in volume in going from the annealed to the hardened state can be calculated. Typical data of this type is shown in Table I.

While the data below is more exact than the "factors," it still does not provide information which will be of practical aid in predicting distortion of tools in

Table I—Volume Changes in Hardening Tool Steel

Grade of Steel	Size of Specimen	Specific Gravity, Annealed	Hardening Treatment	Specific Gravity, Hardened	% Volume Change in Hardening
Carbon Tool Steel	⅜" dia. x 1⅛"	7.865	1450°F, brine	7.795	+.9%
Carbon Tool Steel	1⅛" dia. x 3"	7.835	1450°F, brine	7.800	+.5%
Carbon Tool Steel	½" wafer cut from center of 1⅛" dia. x 3" piece after hardening	7.855	1450°F, brine	7.835	+.3%
Mn Oil Hardening	½" sq. x 1"	7.853	1475°F, oil	7.805	+.6%
SiMn Shock Resisting	½" sq. x 1"	7.770	1625°F, oil	7.725	+.6%
Air Hardening (5% Cr)	½" sq. x 1"	7.815	1775°F, air	7.795	+.3%
High-Carbon High-Chromium	½" sq. x 1"	7.710	1850°F, air	7.715	—.1%

heat treatment, except under certain specific conditions.

Before attempting to explain how to predict the distortion which may be expected to occur in a given tool, it is necessary to become familiar with five fundamental facts concerning the nature of tool steel:

1. Steels expand when heated; they contract when cooled. This fact is true under all circumstances, except when steels are being heated through their "critical ranges," when the reverse is true.
2. Cold steel is strong; hot steel is weak. It is, therefore, obvious that during liquid quenching operations, where great temperature differentials occur, the cold steel will stay "put," while the hot steel will deform in response to stresses set up by the temperature differentials. The resulting deformation is often called warpage, or is sometimes called "hot upsetting."
3. Martensite (which is the name given to the hard product produced by quenching steel) occupies a greater volume than the annealed steel from which it came. In other words, the hardening of tool steel normally tends to produce expansion.
4. Austenite (which is the name given to the high temperature phase of steels, after heating for the quench, but before the quench has started) occupies a smaller volume at room temperature than the annealed steel from which it came. Since it is possible, under some conditions, to retain austenite in quenched tools, it is apparent that this situation will tend to oppose the expansion which always occurs when martensite is formed.
5. Some types of tool steel are shallow hardening, that is, they harden fully only in the outer layers; *the inner portions do not transform to martensite* during hardening and thus are considered as being "unhardened." The term shallow hardening is relative, as the size of the section involved determines whether a given steel will harden through or not.

In order to understand how the above facts may be of value in predicting distortion, it is necessary to appreciate the fact that distortion is the sum total of the effects of warpage plus the effects of inherent distortion. If these two effects are additive, a large amount of distortion will be noted; if they tend to cancel, the amount of distortion may be negligible. The relative effects of warpage versus inherent distortion may best be considered by dividing the tool steel grades into groups, classified by the type of quenching medium needed for hardening.

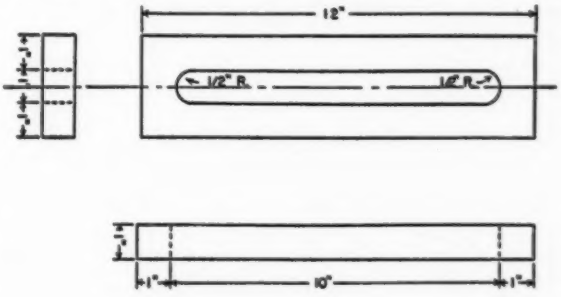
A. Water Quenching Steels

The data in Table I indicate that water-hardening carbon tool steel expands considerably during hardening, as a result of inherent distortion, if the section is small enough so that through hardening occurs. (.9% volume change corresponds to .003" per inch length change.) When the section is large enough to be shallow hardening, the expansion is considerably less, and is in the range of the values shown for oil hardening steels. Since most applications of carbon tool steel involve sizes which do not harden through, it may be logically asked why tools made of this steel distort so much more than other steels. The answer to this question is that inherent distortion plays only a minor part in the distortion of water hardening carbon tool steel; th major part is played by warpage (hot upsetting, or the action of cold steel upon hot steel). Warpage is large because of the large temperature gradients in tools during water quenching. The warpage factor is, to a large degree, controlled by the size and shape of the tool since the geometry of the tool determines which portions will cool first in a quench and which will cool last.

It is a recognized fact that steels such as carbon tool steel, which require water quenching for hardening, are notoriously treacherous with respect to distortion. If a number of identical tools are made up from carbon tool steel and are heat treated exactly alike, it will be found that, after hardening, each tool is of different size and shape. This is due to the non-uniformity of cooling in the quench because of vapor pockets which form on the surface of the tool during quenching. Thus there is a variation in the warpage factor on each tool.

Unfortunately no method exists for evaluating the warpage factor. We are, therefore, unable to predict the distortion of water hardening carbon tool steel except in a general way on the basis of previous experience with tools of similar size and shape.

As an example of the unpredictability of distortion of water hardening carbon tool steel, consider the die shown in Fig. 1. If a die of this type is made up from



SPECIAL DISTORTION TEST PIECE
Figure 1.

carbon tool steel, it will be found that the dimensional changes resulting from hardening are less than .001" per inch except on the thickness, which is better than the results which can be obtained from most air hardening tool steels. The explanation of this result must be that the distorting tendency resulting from warpage counterbalances the inherent distortion and the volume change resulting from the hardening operation appears entirely as an increase in the thickness. (Credit is due for the development of this test piece to A. W. Barndt of Heintz Mfg. Co.)

B. Air Hardening Steels

Because of the small temperature gradients which exist in most tools during cooling in still air, the warp-

age factor is practically negligible in air hardening steels. Under these conditions distortion may be quite accurately predicted using only the inherent distortion "factors." However, tools which have considerable variation in section, or tools which are cooled in an air blast, will not cool uniformly, and thus the warpage introduced will affect the distortion of these tools.

C. Oil Hardening Steels

Tools which are oil quenched have temperature gradients which are larger than those present in air quenched tools but which are not nearly as large as those present in water quenched tools. Oil quenching does not produce vapor pockets, as water quenching does, and, therefore, the size changes which occur in oil quenched steels are reasonably consistent on duplicate tools. Generally, the warpage effects in oil quenched tools are considerably less than the effects of inherent distortion if the section involved hardens completely through. Therefore, inherent distortion "factors" can be used as an approximation of expected distortion of oil quenched steels, although the accuracy of such predictions will not be as good as on air quenched tools. If the tools do not harden through, the use of inherent distortion "factors" will be extremely misleading, and distortion cannot be predicted except on the basis of previous experience.

D. Oil Hardening Steels Quenched in Salt

Quenching of tools in molten salt (Martempering) involves smaller temperature gradients than oil quenching, and thus serves to practically eliminate the warpage factor in the hardening of steels normally hardened by oil quenching. Therefore, the distortion of salt quenched tools can be quite accurately predicted by use of inherent distortion "factors."

The application of the five fundamental facts will now be considered with regard to tools of different shapes:

1. Cylinders

In hardening of cylindrical objects of sizes where the diameter and length are both small, it is invariably found that both the length and diameter expand as a result of the hardening operation simply because of comparatively uniform martensite formation.

In a shallow hardening steel, if a cylindrical part of length considerably greater than the diameter is hardened by vertical quenching (as it always should be), it is practically always found that the diameter increases, but the length contracts. The reason for this will be apparent if the hardening operation is visualized as follows:

a. As the first portion of the cylinder which contacts the water is hardened, the end face and the circumference tend to expand.
b. As additional sections of the circumference harden the outer cylindrical surface expands and tries to take the hot interior with it.
c. In order that the hot interior can expand with the outer surface, hot center metal is "sucked in" longitudinally from the as yet unhardened steel, thereby contracting the length considerably before the upper face end can be hardened.

In view of the actions described in the preceding two paragraphs, it should be apparent that there is a certain size of cylinder, for a given grade and set of quenching conditions, which will not change length at all in the hardening operation. When the above conditions are determined, it is universally true that an increase in the length of this cylinder will result in contraction of the length of the cylinder in hardening; conversely a decrease in the length will result in expansion of the length in hardening. However, when working with a deep-hardening steel expansion in all directions will usually occur, to a degree indicated by inherent distortion "factors."

2. Long Rectangular Shapes

As an actual example of how shallow versus deep-hardening will affect long tools, consider the hardening of two shear blades about 1" x 4" x 120.000" and 2½" x 6" x 120.000" made of a Si-Mn shock-resisting steel. After hardening to C58 Rockwell, it will be found that the 1" x 4" blade will be about 120.250" long while the 2½" x 6" blade will be 119.875" long. The thin blade hardens through, and thus expands in all directions because of martensite formation. The thick blade does not harden through and contracts in length by the mechanism just described for long cylinders.

3. Short Rectangular Shapes

Generally speaking, short rectangular solid dies will expand in all directions as a result of the hardening operation if the section hardens completely through. On air hardening steels, the amount of expansion can be accurately predicted using the inherent distortion "factors." For oil hardening steels, the amount of expansion can be *estimated*, if too great accuracy is not expected. The following example (in Table II) will illustrate this point, having been picked to show the amount of error which may ordinarily be encountered in predicting size changes in oil hardening steels.

The change in volume occurring on this die is .55%,

Table II—Distortion of Mn Oil Hardening Steel Die

	Before Treatment (Annealed)	After Hardening Treatment (*)	Size Increase, Inches	Size Increase, Inches per Inch
Length	5.7688	5.7720	.0032	.0006
Width	1.7501	1.7542	.0041	.0023
Thickness	1.3760	1.3796	.0036	.0026

(*) 1475°F, oil quench, 400°F temper.

which corresponds to an average linear change of .00175 inches per inch. The position may well be taken that the actual change in inches per inch is not very close to the linear "factor." However, with each dimension expanding .003 to .004 inches the "cleaning up" of this die is a simple matter. The variation in these results from those predicted by use of inherent distortion "factors" is a measure of the degree to which the warpage factor has influenced the distortion of the die.

Table III—Distortion of Mn Oil Hardening Steel Die

	Before Treatment (Annealed)	After Hardening Treatment (*)	Size Change, Inches	Size Change, Inches per Inch
Length	11.5010	11.4890	—.0120	—.0010
Width	5.5004	5.5147	+.0143	+.0026
Thickness	2.2506	2.2574	+.0068	+.0030

(*) Same as in Table II.

As an example of the errors which can result from misuse of inherent distortion "factors," consider the data in Table III, which shows the distortion of a die roughly twice the size of the die in Table II. The increase in volume occurring in the hardening of this die is .46%. This figure is lower than normally expected for this grade, and indicates that the die did not harden completely through, thus accounting for the shrinkage in length. It is obvious that inherent distortion "factors" cannot help in predicting the distortion on a die of this type.

4. Ring Dies

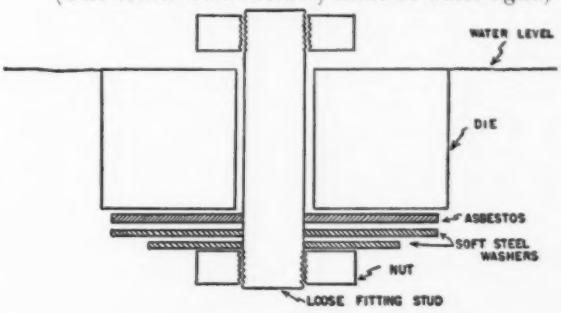
As a further example of the use of the basic principles outlined, consider the hardening of a ring die. It is common knowledge that a heat treater "shrinks" the bore of ring dies in heat treatment by quenching through the bore. This may seem inconsistent with previous statements, wherein it is pointed out that the formation of martensite by quenching always causes expansion. Further consideration will show that this is not inconsistent, since the contraction is actually caused by the expansion due to martensite formation. If the hardening of each segment of a ring is visualized, it can be seen that the ring will expand at the bore surface. However, the net effect of expansion at the bore surface actually results in contraction of the bore diameter. Another way to visualize this action is to realize that the diametrical expansion of a bar will occur whether the bar is straight or "rolled up" in the shape of a ring.

When a ring die is liquid quenched all over, the O.D. will invariably increase, while the I.D. may move slightly in either direction, depending upon the relative dimensions of the die. If a ring is thin in comparison to wall thickness, the hardening of the faces will control the net distortion due to their relatively greater area presented to the quench. This type of ring will increase in thickness and will usually decrease in O.D. and increase in I.D. If the hole in a die is so small that effective quenching through the hole cannot occur, or if the hole is packed to prevent quenching in the bore, the hole will enlarge due to the fact that it "goes along" with the rest of die in its expansion due to martensite formation.

Ring dies made of air hardening steels will enlarge in both O.D. and I.D. in amounts calculated from inherent distortion "factors." However, if it is desired to have the bore close in, this can be accomplished by air blast quenching through the bore.

There is another application of the basic principles which is in common use for shrinking the bore of ring dies. The bore of a ring die can be "closed in" about .002/.003" per inch of bore diameter by this method, which involves:

1. Heating the die uniformly to approximately 1800°F.
2. Quenching the die, on the rim only, to 500°F, while avoiding a quench in the bore. See Fig. 2 for a sketch of the apparatus used in this step. (The center bolt assembly must be water-tight.)



SECTIONAL VIEW OF APPARATUS FOR SHRINKING THE BORE OF A RING DIE
Figure 2.

3. Reheating to the proper hardening temperature.
4. Quenching through the bore only, while avoiding a quench on the rim.

The explanation of how this method works is that (a) the quench on the rim causes the metal in this location to contract, thus "hot upsetting" or warping the adjacent hot metal towards the bore; (b) stopping the quench at 500°F does not permit the formation of martensite and thus does not set up any opposition to the contraction forces; and (c) the subsequent quench through the bore further contracts the bore diameter by the inward expansion resulting from martensite formation.

REFERENCES

1. Howard Scott, "Dimensional Changes Accompanying the Phenomena of Tempering and Aging Tool Steels," Transactions, American Society for Steel Treating, Vol. 9, 1926, Page 277.

(To be continued Sept.-Oct. issue)

Molybdenum and Boron Steels

By NORMAN TISDALE
Molybdenum Corporation of America, Pittsburgh, Pa.

For many years the companies who have been interested in the heat treatment of steel have had as one of their reliable materials a molybdenum steel but in the current struggle molybdenum was practically the second casualty, nickel being the first. Our government decided that in the interest of defense, supplies of molybdenum should be made available for purposes which would be entirely in line with fighting a successful war.

Molybdenum has been used as a substitute for tungsten in high speed steels and a certain amount of nickel in the carburizing grades. Many bolt steels have changed their analyses to the chrome molybdenum type and it would be quite easy to go along relating the substitution of the molybdenum type steels for almost every one of the common variety of alloy steels, all of which has contributed to the shortage of molybdenum.

As a measure to save molybdenum for special purposes, a number of the leaner alloy steels have been substituted and today we find such grades as 8000, 8600 and 9400 being the major percentages of alloy steel produced. These references apply entirely to the commercial grades of steel which are regularly subjected to heat treatment.

Instead of steels carrying .25-.40 molybdenum, .80-1.10 chrome, 3.00-3.50 nickel, new specifications are resulting in steels containing .50 nickel, .30 chrome and .15 molybdenum maximum, and it is being ascertained that their response to heat treatment will not be anywhere near as consistent as the former standard grades. It would seem that to those who are quenching in oil, a faster quenching oil will have to be utilized in order to obtain the possible benefit from these small percentages of alloys. It does not seem reasonable that the quenching temperatures will vary materially, but in order to obtain a proper Brinell Hardness the drawing temperatures should be reduced in some cases as much as 250°.

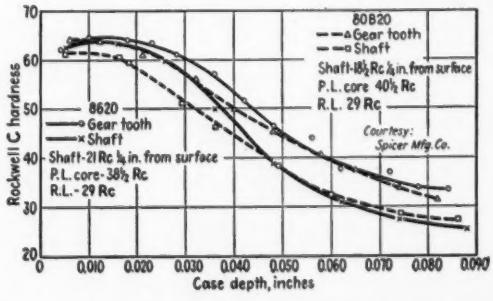
In order to enhance the properties of these low alloy steels, boron has been added as an additional alloy. For practically every purpose that you find a boron composition it will be necessary to liquid quench in order to obtain its added value, and in addition to this, drawing temperatures will have to be held down usually below 1100°, otherwise extra hardenability that boron imparts to quench steels will be lost.

Fifteen years of experience with the use of boron in steel has established the definite fact that unless the steel has been made properly there will be some difficulty due to non-uniformity. There is, however, no excuse today for such non-uniform results because practically every steel company knows how to make boron alloy steels properly.

The addition of boron may be effected by one of several alloys but essentially the amount used is usually between .001 and .003%, and when real large cross sections are encountered the increase in the depth of penetration of the hardness is not over a half inch. Similarly, in cross sections where the present analysis would quench throughout the cross sections, very little will be gained by the addition of boron. Boron's average increase value amounts to practically 15% in the elastic limit and ultimate strength values of a steel which has not had boron in its composition.

At the present time there is contemplated a very large program which will use tonnages of steel containing boron that have been unheard of in the past. Therefore it will be to the advantage of everyone engaged in the heat treatment of steel products to familiarize themselves with the heat treating technique which is necessary to obtain the maximum results with a boron alloy steel. A large number of steels which were formerly classified as a carbon steel will be found in common use but added to their composition will be boron, and they in turn will be utilized for such parts as studs, bolts and many screw machine products.

Strangely enough a decided advantage can be obtained from machinability when boron is part of the



Hardness gradients across carburized and heat treated countershafts made from both 80B20 and 8620 steel. These shafts were treated on a reheat cycle, pitch line and root line hardnesses are shown.

Courtesy, The Iron Age

composition. The average physical properties that can be obtained by a grade of steel known as 4130, will compare quite favorably with the same grade as 3130, the difference being the 4100 series is to be water quenched, whereas the 3130 is to be oil quenched. In the case of the 81B00 series and the 86B00 series, you will not find any great difference in handling this material as compared with a standard nickel molybdenum steel. In other words, the time at heat, the quenching temperature and the drawing temperature may not be much different from standard practice.

A comparison of two steels, one alloyed with boron, and both subjected to identical treatments, reveal some interesting figures. Both steels were oil quenched at

1500°, drawn at 1000° in section size of 1″ round, and the following properties were obtained:

	SAE 1035	SAE 1035 plus boron
Ultimate strength, psi	108000	120000
Yield point, psi	88000	108000
Reduction of area	62%	61.4%
Elongation	23%	20.5%

Note that the influence of boron is primarily on the ultimate strength and yield point and that there is a slight falling off in the ductility. This, of course, can be fully explained by the increase in hardenability.

The effect of boron in its hardening action can be described by stating that it forms a compound known as iron carbide-iron boride (Fe_3C-Fe_2B) and this is usually located in the grain boundaries. The action of boron in a sense is something like that of molybdenum in that it retards the rate of transformation and thus provides a greater depth of hardness penetration. However, this effect is not nearly as great as that produced by molybdenum.

In tool steels which have been made by the electric furnace process, it is usually necessary to maintain a high boron content, that is up to .0035, because inherently this grade of steel made by such a process contains more nitrogen than an open hearth variety. The induction type steel may possibly contain a slight increase of nitrogen over that of the electric furnace process; however, the effect of boron is probably about the same as in the open hearth because, usually, the content is about .0025, whereas in the electric furnace type it will be approximately .003, and this difference in boron content is usually locked up with the nitrogen so that the effect of boron is about the same and the results are equal in the physical properties.

Since the effect of boron is to coarsen the grain size

HARDNESS OF 8620 and 80B20 STEEL

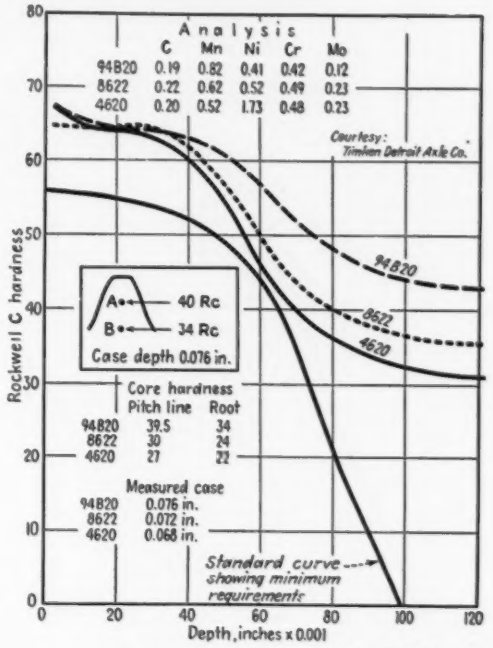
Steel Grade	8620	80B20	8620	80B20
Furnace type	Continuous gas carburized		Pit carburized	
Heat treatment	Carburized at 1700° F Cool to 1100° F Reheat to 1550° F Oil quench Drawn at 340° F		Carburized at 1700° F Cool to 1550° F Oil quench Drawn at 340° F	
File hardness on shaft	0-0.0002 in.	0.0032 in.	0-0.0002 in.	0-0.0002 in.
Hardness P. L.	File hard	File hard	File hard	File hard
Surface Rc	62-62.5	58.5-59.5	60.5-61	61-61.5
Rc ¼ in. below surface of shaft	21	18.5	18	18
Rc tooth core at pitch line	38.5	40.5	29	37
Rc tooth core at root line	29	29	22	28

	C	Mn	Ni	Cr	Mo	Si	B
8620	0.18	0.71	0.45	0.45	0.18	0.24	.....
80B20	0.21	0.53	0.35	0.28	0.10	0.28	0.001

Carburized simultaneously with regular production parts to 0.040-0.050 in. case depth with furnace cycles indicated.

Courtesy, The Iron Age

Case hardness gradients of three steels carburized and quenched together. The minimum hardness required v. depth is shown for these heavy-duty hypoid pinions on the heavy line. For satisfactory service, the hardness must exceed these calculated minimum values.



Courtesy, The Iron Age

slightly, some of the shallow hardening tool steels contain boron to enhance the hardenability. Others will contain boron and will have had no compensation or adjustment to eliminate this coarsening effect, so that when heat treating boron alloy tool steel it is well to be familiar with the practice used in its manufacture, since of course, there is a decided difference in both warpage and response to heat treatment between a coarse and fine grain steel.

The usual application for commercial steels is between .20 and .60 carbon and in those cases the boron content can be up to .0035.

In the case of carburizing steels, boron has been used quite successfully and it should be pointed out that core strengths due to the greater penetration of hardness may be higher than normally encountered, and it is possible that manganese contents may be somewhat reduced to take care of unnecessary high core strengths.

In the case of carbon steels above .60 carbon, a condition is found where hardenability has been increased by the extra amount of carbon so that the user or maker of steel is faced with using a low carbon plus boron or boron in a larger section of the higher carbon. As an example, a grade of .90 carbon steel up to 1½″ round was used without boron but when the size increased to 2″ and 3″, the depth of hardness obtained after heat treatment was not satisfactory for the application requirements. Therefore, in this case an addi-

(Continued on page 23)

Hydrogen and Heat Treating

By CARL A. ZAPFFE, M.S., Sc.D.
Consulting Metallurgist
Baltimore, Md.

If you are a heat treater handling steel, you may run into two different kinds of experience with hydrogen gas absorbed by the metal: (1) putting it in or (2) taking it out.

(1.) Hydrogen Pickup during Heat Treating

First, you may unknowingly inject an important amount of hydrogen into the steel during annealing or hardening heat treatments. You do this by allowing moisture to come in contact with the hot steel. Moisture is made up of molecules containing two atoms of hydrogen and one of oxygen—by symbol: H_2O—and any scaling or oxidation of the surface caused by moisture accordingly releases hydrogen gas at the same instant that the oxygen passes from the water to the metal surface. This reaction takes place in nearly every heat treating furnace, because fuel gases usually contain or develop large quantities of moisture. Even normal humidity itself can be responsible for the reactions in question.

In short, heat treaters should be warned to recognize that moisture at high temperatures is a sort of analog for the reducing pickling acids at low temperatures, so far as contributing hydrogen to steel is concerned. Everyone now knows of the hydrogenizing caused by acid pickling. The information on steam, however, was only recently discovered (see Dec. 28, 1950 issue of *The Iron Age*). Its importance should require every heat treater to study the possibility that important proportions of ductility and workability are being lost in current practice because of hydrogen picked up from steam in the heat treating atmosphere.

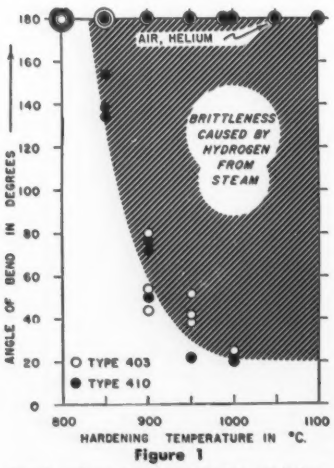


Figure 1

Bend values for martensitic stainless steel hardened over a broad temperature range in atmospheres containing different amounts of water vapor.

Figure 1 illustrates the scope of the effect. Two stainless steels are used as examples, but the data apply more or less to any steel whose ductility can be altered by hydrogen, hence particularly to steels hardenable by the martensite transformation. The specimens were heat treated in a laboratory furnace containing several special atmospheres. Their ductility was measured in terms of bendability by means of a special bend test.

When quenched either from atmosphere of ordinary air or helium, all specimens developed a full bend of 180 degrees.

However, when steam was admitted to the heating atmosphere, the ductility was damaged as indicated by the shaded area. The research from which these data were taken then went on to show that steam admitted even for one minute at the close of a 15-minute anneal in dry helium caused the same injury as an exposure to steam for the entire fifteen minutes. It was also shown that the normal humidity in air can often lead to an important loss in ductility for certain steels.

So far as the extent of damage is concerned, there are two factors principally involved. One is the sensitivity of the steel to hydrogen, and the other is the extent to which the particular steel rips apart the water molecule and frees the hydrogen during scaling. The first largely depends upon carbon content and hardness, the more hardenable the steel the more sensitive to embrittlement. The second can be understood as a function of the "deoxidizing power" of the steel. That is, steel having an appreciable content of strongly deoxidizing elements, such as carbon, silicon, chromium, and so forth, will tear apart the water molecule with greater force than one lacking these constituents. Laws of chemistry then relate the force of this reaction to the force with which the simultaneously freed hydrogen atoms tend to penetrate the steel.

While much explaining would be necessary to give an adequate account of this subject, the important point from a practical perspective is this: Whatever the steel you are heat treating, and whatever the operation, it is likely that you are now unknowingly suffering a loss in the workability of your steel because of hydrogen picked up from steam-metal reactions during heat treatment.

If this hits home, then the next step should be taken in correcting the condition—either get the gas out, or stop putting it in.

(2.) Removing Hydrogen

As for removing gas already in the steel, moderate baking treatments are often applied where hydrogen embrittlement is thought to be a factor. The temperature range is usually limited on the top side by requirements of hardness. Where this is no factor, the next limit develops near 1100° or 1200°F., above which the rate of hydrogen removal reverses in favor of the gas remaining in the steel.

Temperatures commonly vary from that of boiling water on up to 700° or 800°F. The thicker the section, the greater the time required to gain an equal improvement. The composition and condition of the steel also greatly influence the rate of hydrogen removal, so that it is impossible to state any temperature and baking

(Continued on page 18)

we put our heads together with NEW PROCESS GEAR CO. over this heat treating problem...

AEROHEAT® 1200 reduces sludging and increases pot life 20%

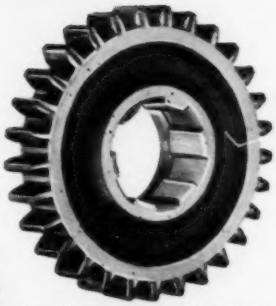
After pack carburizing gears, the New Process Gear Company of Syracuse, N. Y., was encountering undesirable sludging of the transfer salt. New Process engineers realized that a reduction in sludging would simplify processing considerably.

A Cyanamid service representative went into the problem with them. Together, they found a practical solution using Cyanamid's AEROHEAT 1200. Gears were pack carburized at 1680°F for eight hours to a case depth of .040". Then they were transferred to an AEROHEAT 1200 salt bath, held there 1½ to 3 minutes, and oil quenched.

Results? Sludging was minimized and pot life improved 15 to 20%.

Let Cyanamid technical service and heat treating compounds team up to help you meet high specifications required on defense and civilian contracts . . .

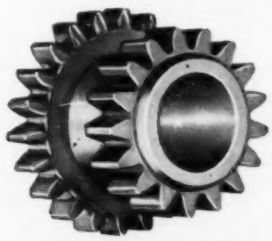
Next time, call Cyanamid first.



Low Slider Speed Gear SAE 4027.

Gear Transmission Main Shaft Third Speed SAE 4027.

Gear Transmission Main Shaft Fourth Speed SAE 4027.



Cluster Gear, like all other gears, hardened to 58-62 Rockwell C. SAE 4027.

Female TRACTA joint for universal SAE 4032.

Cyanamid's heat treating compounds include:

AEROCARB® Carburizing Compounds
AEROCASE® Case Hardening Compounds
AEROHEAT® Heat Treating Compounds

District Offices: Boston • Philadelphia • Baltimore • Charlotte Cleveland • Chicago • Kalamazoo • Detroit • St. Louis • Los Angeles
In Canada: North American Cyanamid Limited, Toronto and Montreal

MT7

AMERICAN Cyanamid COMPANY

INDUSTRIAL CHEMICALS DIVISION
30 Rockefeller Plaza, New York 20, New York

☐ Send technical data sheet on AEROHEAT 1200.
☐ Have technical service representative call.

*Name*_____ *Position*_____

*Company*_____

*Address*_____

*City*_____ *State*_____

Institute News . . .

SPRING MEETING IN COLORADO

The annual Spring meeting of the members of the Metal Treating Institute, New Rochelle, N. Y., whose membership comprises some 70 commercial heat treating plants throughout the United States, was held in Glenwood Springs, Colorado, May 27-30, 1951. Nearly 75 members, from 28 member companies, wives and families were present. Eastern representatives combined to secure a through private Pullman Car which took them via the Southern route through the beautiful Royal Gorge with its famous Suspension Bridge. At this point the train pauses for about 15 minutes to allow close inspection of the bridge and the Cog Railway running from the highway some 3000 feet above the gorge. A highway bridge also crosses the gorge at this point.

On Monday, May 28 Regional National Production Authority officials George Joslyn and T. J. Fitzgerald addressed the group on the subject "Where Do Heat Treaters Stand Under Present Regulations Affecting MRO Supplies Including Nickel and Other Alloyed Products" and a technical paper entitled "The Effect of Boron on the Physical Properties of Steel" by Norman F. Tisdale was also presented by A. M. Cox, Pittsburgh Commercial Heat Treating Co. Mr. Tisdale was unable to be present. (See Page 6.)

Tuesday, May 29 was devoted to the business session with the banquet being held that evening.

On Wednesday, the 30th, a private bus was chartered for an all-day tour to surrounding countryside, including the world famous ski-lift at Aspen, Colorado and the famous ghost town of Marble, the total population of which is now about six people where formerly over 10,000 had formed a thriving community. About ten years ago an avalanche of snow and mud practically wiped out the town without loss of life, resulting in the closing of the famous marble quarries in the district.

The chartered bus took a group from Glenwood Springs to Colorado Springs for a day stop-over of sightseeing and then on to Denver where the rail voyage was resumed.

The 1951 Annual Meeting of the Institute has been set for October 12, 13 and 14 in Detroit, Michigan. Hotel Detroit-Leland has been selected as headquarters.

C. W. Derhammer, President of The Lakeside Steel Improvement Co., Cleveland, Ohio, engaged in Scientific Commercial Steel Treating, has announced the plans for a second story to their present office building, to be used as a physical and chemical laboratory, and for metallurgical research. Edw. G. Hoefler is the architect. A Certificate of Necessity has been approved by the Government for an expenditure of $25,000.

METAL TREATING INSTITUTE OFFERS OPS FULL COOPERATION

Immediately upon learning of plans of the OPS to issue regulation directive covering services, the Institute offered the complete cooperation of its members. Correspondence is reproduced below.

May 10, 1951

Mr. Harold Leventhal, General Counsel
Office Price Stabilization
Temporary Building E Washington, D. C.

AM ADVISED OPS CONSIDERING CPR DIRECTIVE FIXING PRICE FOR INDUSTRIAL SERVICES PERFORMED FOR METAL AND METAL PRODUCTS THIS OF COURSE WOULD INCLUDE THE COMMERCIAL HEAT TREATING INDUSTRY WHOSE PLANTS ARE NOT MANUFACTURERS THE METAL TREATING INSTITUTE WHOSE MEMBERSHIP IS COMPOSED OF 68 COMMERCIAL HEAT TREATING COMPANIES OFFERS ITS FACILITIES AND COOPERATION IF THEY CAN PROVE HELPFUL IN THIS CONNECTION PLEASE ADVISE

C. E. Herington, EXECUTIVE SECRETARY
METAL TREATING INSTITUTE

OFFICE OF PRICE STABILIZATION
Washington 25, D. C.

In Reply Refer to:
Code 2144 June 25, 1951

Mr. C. E. Herington, Executive Secretary
Metal Treating Institute
New Rochelle, New York

Dear Mr. Herington:

We acknowledge and thank you for your telegram of May 10, 1951, addressed to Mr. Harold Leventhal in which you have so kindly offered the facilities of your organization in connection with preparing a ceiling price regulation covering industrial service trades.

As you no doubt know, there was issued on May 11, 1951, Ceiling Price Regulation 34, titled "Services." (copy enclosed) You will note, however, that the service operation of heat treating, in which you are interested, is excluded from the coverage of Ceiling Price Regulation 30 and will remain under the General Ceiling Price Regulation.

May we thank you again for wiring us.

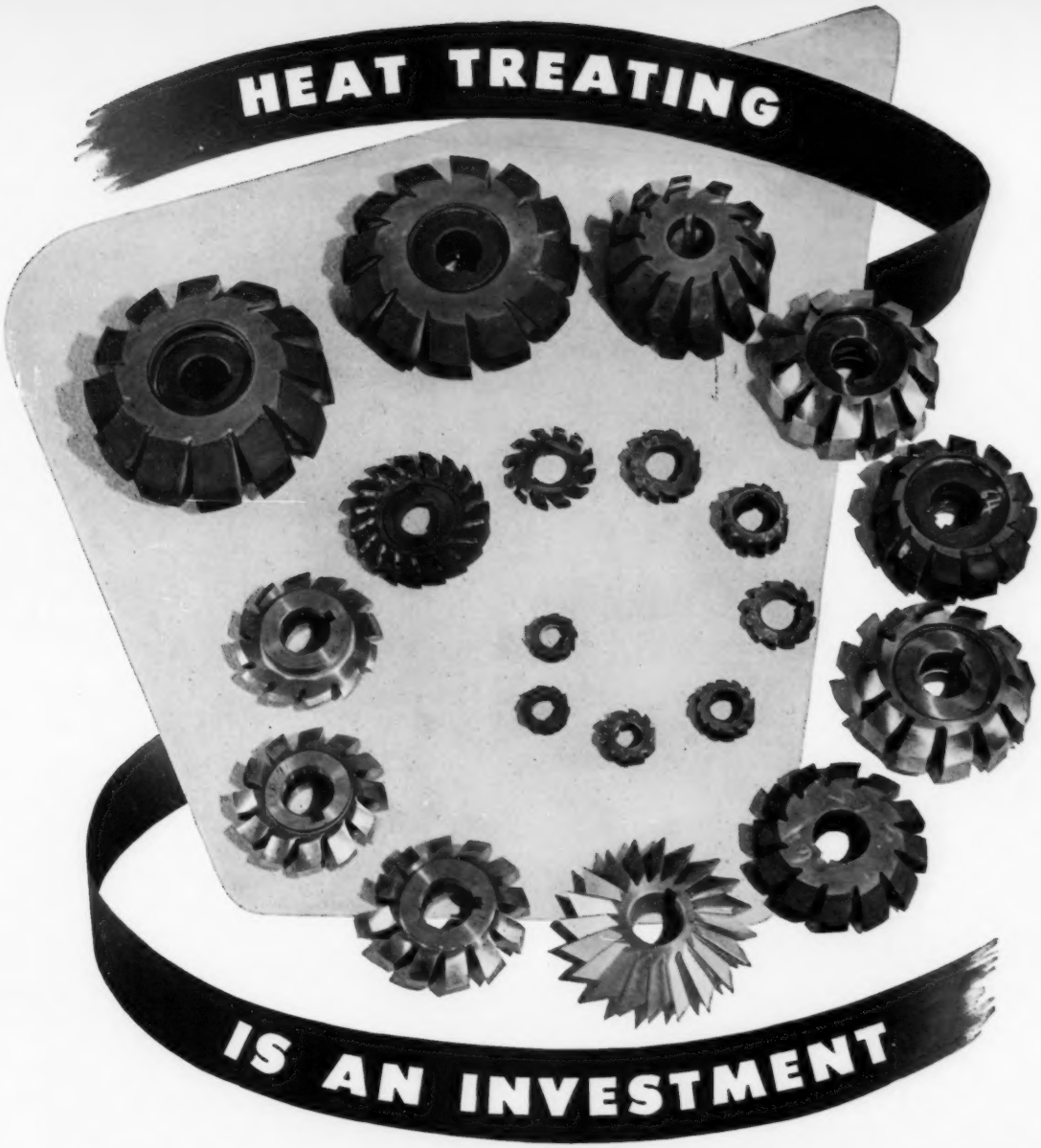
Very truly yours,

L. J. Carson
Chief, Machinery Branch
Industrial Materials and Manufactured Goods Division

Enclosure

We welcome to membership in the Metal Treating Institute California-Doran Heat Treating Co., Los Angeles, Calif. This company is one of the largest on the Pacific Coast with 67 furnaces and employing about 80 people. Operations include nearly all commercial heat treating processes. Mr. Robert Sherwood, Vice President, was a welcome guest at the MTI Spring Meeting in Glenwood Springs, Colorado. During the meeting Mr. Sherwood contributed some very helpful information about the commercial heat treating industry in Los Angeles and has volunteered to round up some worthwhile members in his area.

(Continued on page 13)



Depending on the shop that is doing it, HEAT TREATING can be just "another job" . . . OR, A REAL INVESTMENT!

These cutting tools, for example, represent top-grade tool steel, plus many skilled man-hours . . . they cost real money. The heat treating means only a few cents more by comparison. But in those few cents can be represented many hours of dependable tool service, or the failure of the tool after only a short period of use.

Here at Lansdale we consider every job as an investment. We put everything that we have in the way of modern knowledge, experience and equipment into *every* job regardless of size or quantity. The result—a constantly growing list of satisfied customers.

Call us at LANSDALE (PA.) 4611 for a quotation on your work.

REX

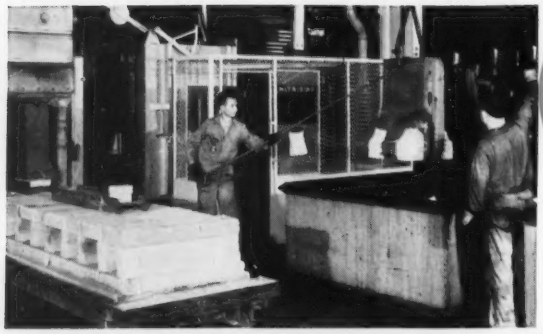
J. W. REX CO. *Successors to REX & ERB*

Consultants and Specialists on Modern Heat Treatment

Plant and Laboratory LANSDALE, PA. Phone: Lansdale 4611

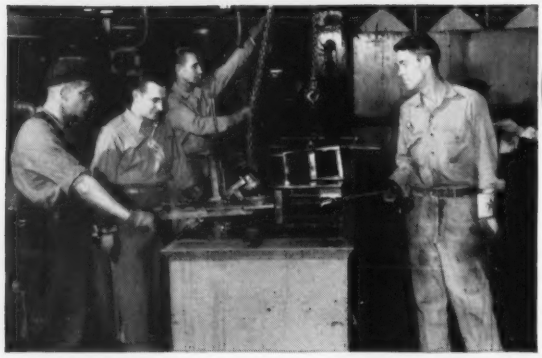
NEW SUPER QUENCH OIL..

. . . GIVES YOU TRIPLE ACTION!



1 FASTER, DEEPER HARDENING

Mineral intensifiers give Park Triple A Oil faster quenching speed through the critical range, resulting in faster and deeper hardening.



2 LESS DISTORTION

Fast, uniform hardening in the critical range, plus a low cooling rate through the temperature zone of martensite formation, means less distortion from Park Triple A Oil.

3 BRIGHT QUENCHING

Special anti-oxidants used in Park Triple A Oil give it greater stability for longer life and bright quenching properties. This is important when work is quenched from carbo-nitriding furnaces.

Unretouched photographs of precision parts quenched from a carbo-nitriding furnace in Park Triple A Quench Oil. From left to right are parts quenched the first day, 30 days later, 60 days later, and 90 days later. Bright and clean after over 3 months use with no indication of reduction of surface cleanliness.

For Hot Oil Quenching up to 450° F use Park Thermo Quench Oil. Send for Bulletin No. F-7.

For These Critical Times . . .

Now more than ever you will need Park Triple A Quench Oil . . . with steels of critical hardenability due to lean alloy content and parts manufactured under government contracts, you can't afford costly rejects due to rigid inspection. Get the most from your quench oil — get Park Triple A Quench Oil today and save on critical material and expensive rejects. Send for Bulletin No. F-8 today, for complete information.

Park

CHEMICAL COMPANY

8074 Military Ave., Detroit 4, Mich.

Institute News (cont.)

Earl P. Brane, President of the Nerl Heat Treat Corporation, South Bend, Indiana writes that he is expanding his business by the formation of a new company in Indianapolis, Indiana. He states: "Our new business will be Indianapolis Metal Processing Co., Inc., 612 Park Avenue, Indianapolis, Indiana; President—Earl P. Brane; Vice President—J. M. Tucker; Plant Supt.—Ralph Orton (formerly with Nerl Heat Treat Corporation). Building is cement block and brick, with 20 ft. ceilings and steel roof—approximately 6,000 sq. ft. of floorspace. At present we are planning on concentrating primarily on aircraft work. This will include: Air Corps certified welding, heat treating, magnaglow inspection (5000 amp. capacity), zyglow inspection, sandblasting, plating and anodizing for both steel and aluminum."

L-R Heat Treating Co., Newark, N. J., has expanded its facilities by building a new addition to its plant. The new structure adds another 4,000 sq. ft. of floorspace. Some half dozen pieces of heavy type equipment have also been purchased by L-R Heat Treating Co. in connection with its expansion program.

Editorial (cont.)

proof that such generous values were essential to safe performance.

In order, therefore, to obtain the maximum production of steels necessary for today's demands with a minimum use of scarce alloying elements, we suggest that very careful study be given by metallurgists and engineering experts to determine to what extent elongation or reduction of area values called for in current specifications might be reduced without danger to the satisfactory performance of the product. Certainly this is no suggestion that anything approaching "brittleness" be permitted in steels for defense purposes.

Not only would this, if successfully accomplished, greatly aid the conservation program, but it would also alleviate the difficulties of the competent heat treater in getting required results from lean steels, which by their nature often fail to come up to the performance which the richer alloyed materials can be depended upon to give.

As a consequence of such a policy, enormous savings might be made by avoiding losses of steel and of labor due to the rejection of parts simply because they have not come up to the full prewar requirements for elongation or reduction of area.

THERMO-COUPLETTES . . .

Annealing Spider

A new type Annealing Spider has just been announced by KIF Industrial Fabricators, North Haven, Conn. As contrasted to conventional cross-member construction, a large central pipe, with eight smaller pipes welded to its perimeter, holds the wire coils round with only a line contact. This construction affects an equal distribution of heating and cooling forces which prevents warping during the annealing process. Designed to minimize warping, give longer life and reduce loading and stripping friction in wire annealing, the new KIF Annealing Spider has many meritorious mechanical, construction and operating features.

With an overall height of 81 inches, any diameter can be furnished to meet individual needs within a range of 10 to 30 inches. It can be furnished with either solid or removable bottom plates to suit any stripping method.

The manufacturer claims that the KIF Annealing Spider eliminates the costly discarding of spiders because of being badly warped out of shape or because they are impossible to load or strip. It is also claimed that the KIF Annealing Spider prevents damage to wire during the annealing operation and minimizes lost production time due to damaged wire.

New Industrial Baking Oven

A new type, small, gas-fired baking oven for industrial purposes proves especially useful for (1) baking or tempering small production orders, (2) for heating samples, so that when large production orders are heated at the same temperature in large ovens, the results will be the same, and (3) for use in shops and laboratories for research, testing, precipitation hardening of beryllium-copper and other alloys, relieving hydrogen-embrittlement, drying cores, baking molds and plastics, and for many similar uses. Outside dimensions are 14″ wide, 16″ deep and 20″ high. Heating Chamber 10″ wide, 9″ high and 12″ deep with 2 shelves. Capacity is 250° to 650°F. Pyrometer actuated controller, 3″ dial thermometer, 2-60 minute timers, 2″ of insulation. Net Weight 75 Pounds. Made by The Carlson Company, 277 Broadway, N. Y.

Induction Heater

The machine shown was designed for production brazing, soft soldering or heat treating of a wide range of moderate size parts. The machine used a modified drill press in which the mechanism was reversed so that its spring load held the work against the anvil. The chuck was used to secure and center a variety of work holding fixtures.

The Induction Heater is one of a standard line of machines manufactured by Sherman Industrial Electronics Company, Belleville, N. J. and in this case is the 4 KVA Type SI-42. Its operating controls are all at the top of the machine. The load meter reads directly the percentage of the full load drawn by the work. The machine operates in the *megacycle* range. This is particularly important to those concerned with the brazing or soldering of brass or other non-magnetic pieces. The unusually high frequency gives much more rapid heating of brass and non-magnetic parts as well as the usual steel parts.

New Radio-Frequency Gear Hardening Machine for High Production

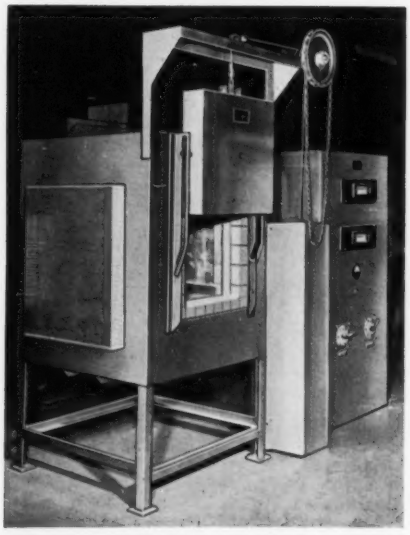
A new radio-frequency gear hardening machine, for high-production heat treating of gears, is available from Westinghouse Electric Corporation.

This machine—the Inductall—is used with a vacuum-tube radio-frequency generator, a 10,000-cycle motor-generator set, and other associated equipment, to harden spur gears, cluster gears, integral spindle gears, and also shafts. The machine carries each gear through an automatic cycle for either through- or contour-hardening. Uniformity of hardening is said to be achieved from the mechanical gear handling system and precise electrical timing of the pre-heat, heat-treat, and quench operations. The Inductall system is flexible, lending itself readily to expansion to meet increased production requirements.

Pereco Announces High Temperature Heat-Treating Furnace for Heavy-Duty Work

Spacious work chamber, accurate temperature controls, and versatile operating features make the new Pereco Model FG-7800 Electric Furnace a useful unit for heavy-duty heat-treating work, according to its manufacturer, Pereny Equipment Company, 893 Chambers Road, Columbus 12, Ohio. It handles all heat-treating temperatures up to 2500°F, with an absolute maximum of 2700°F and can be supplied completely gas-tight with atmosphere connections.

The separate control panel is equipped with voltage-regulating, multi-tap transformer; temperature indicator and controller; magnetic contactor; and a high limit cut-off which acts to safeguard the furnace from accidental overheating.



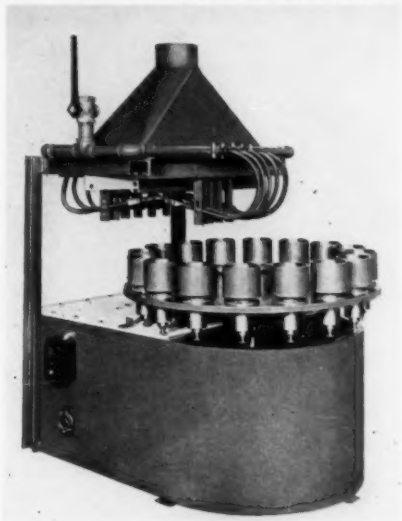
Over-all size of the Model FG-7800 is 33¼" wide, 39¼" long, and 64" high; with a loading area 18" wide, 24" long, and 18" high. This heating chamber is thickly insulated, and the wedge-action door effectively seals the opening. The heavy steel outer case is electrically welded and strongly reinforced. A chain hoist provides easy, vertical operation for the fully insulated door.

Heating elements used in this furnace are the Globar silicon carbide type to reach and maintain temperatures uniformly at all levels within its range. Maximum connected load is 34.5 KW. Operating current is 220 volts, 3-phase.

High Speed Heating Unit for Brazing or Annealing Shells

A new, gas-fired Production Heating Machine has been introduced by Gas Appliance Service, Inc., Chicago. This high speed heating unit is ideally suited for two types of operations: (1) brazing plugs or adapters into ends of shell type units; and (2) appealing mouths of shell cartridges.

The heating zone in this unit consists of two rows of High Speed Zig-Zag Burners. These burners, with their high rate of heat output, bring the sections to be



brazed or annealed to the proper temperature in a minimum time—providing high production rates. This machine confines the heat to the work area and eliminates the usual excessive heating of surrounding portions. Cups which hold pieces are provided with spindles which rotate while passing through the heating zone.

The manufacturer claims production of 600 pieces per hour in a 60" diameter unit. Only one operator is required for loading and unloading pieces on this simple, easy-to-operate machine. Other types and sizes of turntables or conveyor units are available for accommodating various diameters and production requirements.

Bench Blast Cabinet

The W. W. Sly Manufacturing Co., Cleveland, Ohio are manufacturing a bench blast cleaning cabinet which can be held in the hands of the operator (see illustration). The unit provides well lighted, easy visibility and permits rapid and dust free cleaning of small parts.

Expert HEAT TREATING

FOR SPECIAL JOBS OR PRODUCTION RUNS

The House That Heat Built

YOUR TIME and MONEY are PROTECTED at COMMERCIAL STEEL TREATING

The parts you send for heat treating represent your investments of time and money. We appreciate how important it is to you that they be protected by perfect heat treating. Your protection lies in our skilled personnel—top craftsmen who contribute decades of experience to your job—and our complete range of all types of modern equipment.

CALL ON US FOR ADVICE. Our metallurgical engineers are well qualified to help solve your metal-treating problems and we will welcome your inquiries.

Pick-up and delivery service
24 hours a day

Complete Service

- ★ Bright Hardening of stainless steels
- ★ Steam Treating high-speed cutting tools
- ★ Carbo-nitriding
- ★ Carburizing—Liquid, Gas, Pack
- ★ Martempering
- ★ Nitriding
- ★ Austempering
- ★ Salt Bath Hardening
- ★ Cyaniding
- ★ Chapmanizing
- ★ Normalizing
- ★ Atmosphere Control Hardening
- ★ Annealing
- ★ Shrinking
- ★ Seasoning and Aging
- ★ Stress Relieving
- ★ Special Treating
- ★ Deep Freezing
- ★ Silcoting
- ★ Gleason Machine Quenching
- ★ Straightening
- ★ Sandblasting
- ★ Plasmo (special hardening of special dies and hobs)
- ★ Gritblasting
- ★ Liquid Surface Honing
- ★ Malcomizing (for surface hardening stainless steels)
- ★ Kaliding (increases life of finished high-speed steel tools)
- ★ Soditing (for toughening finished high-speed steel tools)

COMMERCIAL STEEL TREATING CORP.

6100 TIREMAN AVENUE • TYler 6-6086
DETROIT 4, MICHIGAN

PERSONALS

Freddie and his Lamb added life to the party

Freddie Heinzelman, Jr., Past President, MTI, was accompanied by Mrs. Heinzelman, and Mr. and Mrs. Fred Heinzelman, Sr. on the Colorado trip. Also Freddie's charming daughter, Louise, age six, who added lots of life and interest to the party.

On the train, Past-past President Horace Knerr came up with the following commentary on the situation, without apologies to Henry W. Longfellow or anyone else. This just goes to show that almost anything can be expected from a heat treater.—*Editor*

LOUISE HEINZELMAN

Freddie had a little lamb,
Her hair was shining gold
And everywhere that Freddie went
Her hand he loved to hold.
He took her on a trip one day
To far off Glenwood Springs.
She saw some sheep along the way;
Fat steers and other things.
She gambolled up and down the aisle,
Kept Freddie on the run
And with her bright and elfin smile
Made friends with every one.
She saw some mountains topped with snow,
A river running fast,
But when it's time, she'll gladly go
With Freddie home at last!

* * * *

Mr. Victor Bozick was promoted from Plant Superintendent to Works Manager, effective June 1, 1951 at Pearson Industrial Steel Treating Co., Chicago.

Mr. Carlton M. Fallert, previously associated with Lindberg Steel Treating Company and Montgomery-Ward Company, Chicago, has joined the organization. Mr. Fallert is a graduate of the University of Chicago and is a Metallurgist and Chemist. He will be in charge of purchasing and quality control.

Mr. and Mrs. L. P. Josephs of the Pearson Industrial Steel Treating Company of Chicago (Cicero) recently announced the engagement and forthcoming marriage of their daughter, Lois, and Jack B. Weil, son of Mrs. Ernestine Weil of Chicago. They will be married in the French Room of the Blackstone Hotel.

The bride-to-be is a graduate of the University of California at Berkeley. In September she will enter her final year of law studies at the University of Chicago. Mr. Weil, a public relations director, attended the University of Missouri journalism school and worked for six years as a newspaperman in Chicago.

Mr. Alfred Francis, formerly with International Harvester Company, West Pullman Works, also joined the company the first of July. Mr. Francis was an officer in the U. S. Navy during the second World War. He is a graduate of the University of Illinois with a BS Degree in Metallurgical Engineering, and will be employed as a Metallurgical Engineer in our Sales Department.

Mr. Raymond Eriksen has been engaged as Plant Metallurgist and Superintendent starting July 16, 1951. Mr. Eriksen is a graduate of the University of Illinois and was formerly connected with National Malleable & Steel Castings Company, Cleveland and the Ohio Tool Company, Cleveland, Ohio.

* * * *

Men of leisure do little so-called original thinking; original thinking is done by busy men.

Hydrogen and Heat Treating (cont.)

period which will positively secure a desired result. The best procedure is for each situation to be tested in itself, a minimum treatment then being selected upon the basis of specific results obtained for the piece in question.

In Figure 2, a plot of bend values shows the recovery of bendability by aging for an extended period of time at room temperature. Hydrogen always tends to escape from steel, except when in an actively hydrogenizing environment; and the rate of escape generally increases with increasing temperature, up to the limits mentioned earlier. The graph accordingly shows a recovery of 180-degree bend after about two months of aging. However, it also shows a blackened area, representing a further loss of ductility during the first week. This is a phenomenon common to hydrogen embrittlement, and one which must be given attention. It can be read elsewhere that hydrogen first enters the metal as individual atoms, just like any other solution, and that embrittlement only develops when these atoms subsequently precipitate within the solid metal —just as occurs in hardenable duralumins and copper-beryllium alloys, except that now the precipitate is a trapped gas. This precipitation is evidenced as increasing embrittlement, even though actual absorption of the hydrogen has ceased. Consequently, the metal might become more brittle during subsequent storage than it was immediately after such treatments as pickling, electroplating, or heat treating in atmospheres containing moisture. Most heat treaters—unfortunately —have had opportunities to observe spontaneous cracking in parts which were stored, or on their way to a customer.

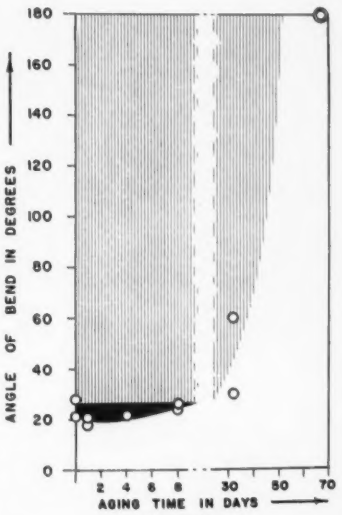


Figure 2

Bend values for Type 410 stainless steel of Figure 1 embrittled by hydrogen from a steam-metal reaction during the hardening anneal, showing recovery of a 180° bend over a period of 2-months aging at room temperature. The blackened area shows a phenomenon of spontaneous embrittlement which often occurs before recovery sets in.

Conclusion

A great deal has been written on hydrogen in steel during the past decade, and anyone desiring detailed information should look up publications on the subject during that period. The fact of its importance has been amply proved; and these recent discoveries in

(Continued on page 23)

LETTERS TO THE EDITOR

4604 - 31st Road S.
Arlington, Virginia

Dear Editor:

I read the recent article "New Quenching Methods Avoid Cracking—Improve Performance" by J. H. Chapman in the May-June, 1951 issue. I feel that the article may be of some use in promoting the concepts of austempering and martempering among commercial heat treaters, but some of the statements therein are in marked disagreement with current theory on the decomposition of austenite.

In addition to the comments by the MTI Publications Committee, I would like to offer the following:

1. The text completely ignores the existence of two distinct knees in alloy steels and that the isothermal products resulting from transformations above and below both knees are known as "pearlite," "fine nodular pearlite," "upper bainite" and "lower bainite" respectively.
2. The text infers that pearlite is the first product to form on slack quenching. Actually proeutectoid ferrite or carbide will form first depending on whether the analysis is hypo or hyper eutectoid.
3. The text infers that M_f is at atmospheric temperature. Actually M_f is considerably below room temperature (thus refrigeration to reduce retained austenite) for many steels in common use today.
4. The statement that "austempering is recommended where a finished product with more than the usual amount of elasticity is desired" is misleading. Perhaps the author is confusing elasticity with yield point or elastic limit. Elasticity which is a function of Young's Modulus is practically the same for all steels, regardless of microstructure.

J. R. HUNT

155 Billings Rd.
Quincy, Mass.

Dear Editor:

Please let me know how I can get on your mailing list for "Metal Treating."

My work as a Methods Engineer, dealing with Heat-Treating problems, requires my being kept informed on all the latest developments in this field.

The magazine is just what the Dr. ordered.

GEORGE NEREO

Rockwell Manufacturing Company
Barberton, Ohio

Dear Editor:

I would appreciate it very much if you would place me on your mailing list to reecive one copy of "Metal Treating."

Thanking you in advance for your early attention in this matter, I am

HANS J. HEINE
Chief Metallurgist

Cook Heat Treating Corporation
Los Angeles 58, California

Dear Editor:

I note with pleasure that you published my article "Establish a Work Flow for Efficient Production" in the May-June issue of Metal Treating. The excellent way you set it up is proof of your ability to unscramble my longhand notes. I regret, however, that I did not fill out the forms illustrated in the article with sample information to make their intent and purpose clearer to the reader.

Speaking of the other articles in this issue, namely those by Herbert Dobkin, J. H. Chapman and David R. Edgerton I gleaned much helpful information from their context of interesting reading matter.

Metal Treating magazine is welcome at Cook and is read by the management and several foremen.

W. W. FARRAR, JR.
Exec. Vice President

(Continued on page 21)

Letters to the Editor (cont.)

Istituto Sperimentale dei Metalli Leggeri
Milan

Request of a specimen copy: "Metal Treating" review.

Dear Editor:

We should be obliged to you if you would let us have a specimen copy of your above said periodical.

I. S. M. L.

Chicago, Illinois

Dear Editor:

A copy of Mr. George D. Prest's letter to you of June 27, 1951, has been referred to me by our sales manager, Mr. L. A. Shea.

Naturally, we here in Chicago receive copies of "Metal Treating" regularly and Mr. Prest of our Los Angeles office has also shown his desire to be a regular reader of "Metal Treating."

The point of this letter, however, is a request from the sales manager's office that you add each of our twenty-two sales offices (outside of Chicago) to your subscriber's list. A roster of these offices and the name of one individual for each office is enclosed. If there are any charges for this service, we will be happy to cooperate with you.

Lindberg Engineering Company
GEORGE W. PERRY
Advertising Department

Cheerfulness is not only a good friend-maker, but it is healthful. The man who is naturally cheerful wards off many a pill and many a doctor's bill. Be short of what you will, but be long on cheerfulness; cultivate it and dispense it; pass it around; the more you scatter it the more you will have left. Cheerfulness is one of the few things you may squander to advantage.

Looking on the bright side never passes a dividend. If things go awry —as things will now and then—take a new grip, and grin! Gloom gnaws at the vitals of the man who lugs it, and deters him from getting on. It slows up things; it's a clog to trade, and makes one's liver sluggish. Gloom uses the breaks, cheerfulness presses the accelerator.

—*Northwestern Union News.*

Manufacturers' Literature . . .

The literature listed below contains information of interest to heat treating organizations. For your copy write direct to the manufacturer and be sure you mention seeing it reviewed in "Metal Treating".

Devine Process Equipment

The J. P. Devine Manufacturing Co., Pittsburgh 1, Pa., has just published a new 8-page illustrated booklet entitled "Devine Process Equipment." Of particular interest to heat treaters is the line of Devine mixers or agitators for quenching tanks.

Pit Type Convection Furnaces

The Hevi Duty Electric Company announces a new Pit Type Convection Furnace Bulletin, IND-451. This illustrated bulletin describes the use, construction and specifications of Hevi Duty Pit Type Furnaces. Installation photographs show some of their important industrial applications.

New Running-Time Recorder

A new bulletin describing the new Series 500 Running-Time Recorders has just been published by The Bristol Company, Waterbury 20, Conn. This bulletin gives information concerning the application of the Running-Time Recorder to continuous ovens and furnaces. The bulletin is liberally illustrated with photos of various models, reproductions of chart records and operation drawings. Photographs of several installations of the newly-announced instrument are also included. In addition, brief descriptions of other Bristol Production Recorders are given. Bulletin OP1504 is available from the company on request.

Micro Cam Oil Valves

Hauck Manufacturing Co., Brooklyn, N. Y., has just published a new catalog No. 704-A describing a small control valve with accurate metering features designed to eliminate guess work in oil burning. The unit is said to be able to prevent smoke by avoiding any excess in the amount of oil going to the burner, particularly useful where local smoke conditions exist.

Heat Treating Case Histories

Ipsen Industries, Inc., Rockford, Illinois, has available Ipsenlab periodic sheets which provide case histories on bright hardening, annealing and carburizing.

Heat Exchangers

Niagara Blower Co., New York 17, N. Y., offer Bulletin No. 96 describing Niagara Aero heat exchangers which are said to permit temperature controls by evaporated cooling, resulting in protection of physical properties and the economies of water and piping equipment.

High Speed Flame Heating

Gas Appliance Service, Inc. is offering an 8-page illustrated bulletin describing equipment for high speed flame annealing, flame hardening, brazing, etc.

Batch Conveyor Type Ovens

Bulletin 4-T offered by Young Brothers Co. describes a line of batch and conveyor type ovens for ferrous, non-ferrous and light alloy heat treating.

They who are content to remain in the valley will not get the grander view from the mountaintop.

* * * *

He who is plentifully supplied from within needs but little from without.

* * * *

A wise man will make haste to forgive, for he knows the full value of time and will not suffer it to pass away in unnecessary delay.

* * * *

Action without thought is like shooting without aim.

* * * *

No one is small who does a small job in a great way.

* * * *

Have patience! All things are difficult before they become easy.—Saadi.

Molybdenum and Boron Steels (cont.)

tion of .003 boron was made and found to give satisfactory results.

In the event hardenability is too great with .003 boron, the amount of hardenability increase which may be obtained by boron additions is almost directly proportional up to .003. Therefore, some requirements might be met with an addition as low as .0005 or progressively upwards to the desired degree of reaction.

Boron steels have been rightly described as presenting "an new era in alloy metallurgy" (Brown—The Iron Age), and their usefulness and benefits will doubtless be further expanded in the coming years.

STRESS RELIEFS

It has been stated many times that money does not make one happy. We won't argue this point, but money sure can keep you miserably comfortable.

* * * *

When you start talking, you are repeating something you already know. Those of us who can cultivate the art of listening are likely to learn something.

* * * *

Quoted from A. B. Homer's recent address in Buffalo: "We can't be rigid on our outlook, if we are going to progress, or even hold our position. As the Irishman said: 'You have to run forward like hell, to stay in the same place.' "

—*Tool Steel Topics*—Bethlehem Steel Co.

Hydrogen and Heat Treating (cont.)

particular, concerning the important effects of steam contacting hot steel, should be given careful consideration wherever it would be advantageous to have greater workability—greater reduction per die, a greater number of reductions between anneals, cold upsetting without cracking, and so forth.

For a recent summary on the effects of hydrogen in steel, see series of aritcles in "Wire and Wire Products," Feb., 1946; May, 1947; June, 1948; July, 1948; Sept., Oct., Nov., Dec., 1948.

February, 1946 issue contains complete bibliography of some forty or move publications by the same authors, treating the various details of the material largely summarized in "Wire and Wire Products."

By the Way

Trouble is usually produced by those who don't produce anything else » »

* * * *

We make a living by what we get; we make a life by what we give » »

* * * *

Time will tell whether a man lays a good foundation for his life » »

* * * *

Never expect a reward for doing your duty.

THE METAL TREATING INSTITUTE

ASSOCIATION OF MASTER CRAFTSMEN

THE MEMBERSHIP - 1951

CALIFORNIA

California-Doran Heat Treating Co.
2850 E. Washington Blvd., Los Angeles 23

Cook Heat Treating Corp.
5934 Alcoa Ave., Los Angeles 11

Lindberg Steel Treating Co.
3537 East 16th St., Los Angeles 23

Industrial Steel Treating Co.
600 Fallon St., Oakland 7

Dexter Metal Treating Co.
1026—77th Ave., Oakland 21

COLORADO

Metal Treating & Research Co.
651 Sherman St., Denver 3

CONNECTICUT

Commercial Metal Treating, Inc.
89 Island Brook Ave., Bridgeport 6

Stanley P. Rockwell Co.
296 Homestead Ave., Hartford 5

ILLINOIS

Accurate Steel Treating Co.
2226 W. Hubbard St., Chicago 12

Chicago Steel Treating Co.
333 North California, Chicago

Dura-Hard Steel Treating Co.
2333 West Deming Place, Chicago 47

Lindberg Steel Treating Co.
222 North Laflin St., Chicago 7

Pearson Industrial Steel Treating
5757 Ogden Ave., Chicago 50

Perfection Tool & Metal Heat Treating Co.
1740 West Hubbard St., Chicago 22

Fred A. Snow Co.
1942 West Kenzie St., Chicago 22

American Steel Treating Co.
P. O. Box A, Crystal Lake

Eklund Metal Treating, Inc.
721 Beacon St., Love Park

O. T. Muehlemeyer Heat Treating Co.
1531 Preston St., Rockford

C. U. Scott & Son, Inc.
1510 First Ave., Rock Island

INDIANA

Metallurgical Service Co.
1020 East Michigan St., Indianapolis 2

Nerl Heat Treat Corp.
1824 So. Franklin St., South Bend 23

MARYLAND

Maryland Tool Company
111-13 Hollingsworth St., Baltimore 2

MASSACHUSETTS

New England Metallurgical Corp.
9 Alger St., South Boston 27

Porter Forge & Furnace, Inc.
74 Foley St., Somerville 43

Greenman Steel Treating Co.
284 Grove St., Worcester 5

MICHIGAN

Anderson Steel Treating Co.
1337 Maple St., Detroit 7

Commercial Steel Treating Corp.
6100 Tireman Ave., Detroit 4

Commonwealth Industries, Inc.
5922 Commonwealth Ave., Detroit 8

Vincent Steel Process Co.
2424 Bellevue Ave., Detroit

MINNESOTA

Metallurgical Control Labs.
2226 East Lake St., Minneapolis 7

MISSOURI

Lindberg Steel Treating Co.
650 East Taylor Ave., St. Louis 15

Paulo Products Co.
5711 West Park Ave., St. Louis 10

NEW JERSEY

Ace Heat Treating Co.
611 Grove St., Elizabeth

American Metal Treatment Co.
Highway 25 and LaFayette St., Elizabeth

B-M Heat Treating Co.
220 Clifford St., Newark 5

Bennett Steel Treating Co.
246 Raymond Boulevard, Newark 5

L-R Heat Treating Co.
107 Vesey St., Newark

NEW YORK

Fred Heinzelman & Sons
138 Spring St., New York 12

Alfred Heller Heat Treating Co.
391 Pearl St., New York 7

Metro Heat Treat Corp.
466 Broome St., New York 13

Precision Heat Treating Co.
216 William St., New York 7

Lindberg Steel Treating Co.
620 Buffalo Road, Rochester 11

Syracuse Heat Treating Corp.
1223 Burnet Ave., Syracuse 3

OHIO

Cincinnati Steel Treating Co.
Wooster Pike & Mariemont Ave.,
Cincinnati 27

Queen City Steel Treating Co.
2980 Spring Grove Ave., Cincinnati 25

Lakeside Steel Improvement Co.
5418 Lakeside Ave., Cleveland 14

George H. Porter Steel Treating Co.
1265-71 East 55th St., Cleveland 14

Winton Heat Treating Co.
20003 West Lake Road, Cleveland 16

Ferrotherm Co.
1861 E. 65th St., Cleveland 3

Dayton Forge & Heat Treating Co.
2323 East First St., Dayton 3

Ohio Heat Treating Co.
1100 East Third St., Dayton 2

PENNSYLVANIA

Robert Wooler
Limekiln Pike, Dresher

J. W. Rex Co.
834 West Third St., Lansdale

Metlab Company
1000 East Mermaid Lane, Philadelphia 1

Wiedemann Machine Co.
4272 Wissahickson Ave., Philadelphia 32

Pittsburgh Commercial Heat Treating Co.
49th St. and A.V.R.R., Pittsburgh 1

TEXAS

Cook Heat Treating Co., of Texas
6233 Navigation Boulevard, Houston 11

WISCONSIN

Wesley Heat Treating Co.
825 South 21st St., Manitowoc

Hushek Metal Processing Co.
1536 West Pierce St., Milwaukee

Metal Treating, Inc.
720 South 16th St., Milwaukee 4

Thurner Heat Treating Co.
809 West National Ave., Milwaukee 4

Harris Metals Treating Co.
1745 Taylor Ave., Racine

Supreme Metal Treating Co.
4440 West Mitchell St., Milwaukee 14

Wesley Steel Treating Co.
1301-1403 West Pierce St., Milwaukee

Spindler Metal Processing Co.
2338 Mead St., Racine

Wesley Metal Treating Co.
2320 Mead St., Racine

TOUGH...

- **Generous Sized Cabinets**
- **Conditioned Cooling System**
- **Built-In Checklite System**
- Oversized Components
- **Filament Voltage Regulation**
- **Industrial Type Tubes**

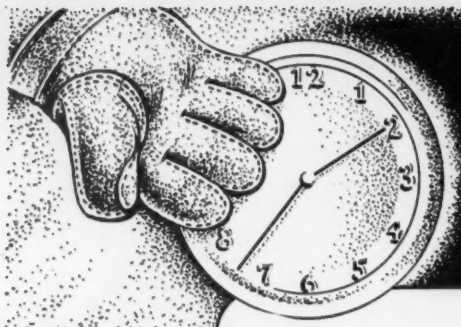
Oversized components built into every unit — industrial type tubes — extra heavy relays — sturdy insulators — in fact every part contributes to the extra value of the total — insuring uninterrupted production and hundreds of "bonus hours" of service life.

Yes, tough . . . and dependable! Lindberg Induction Heating Units are built to take punishment—like a well trained and conditioned champion, they absorb punishment under rigid production requirements far beyond the usual capabilities of induction heating equipment—and keep on giving dependable service . . . 24 hours a day . . . day after day.

In plants all over the country, these units are delivering a versatile, dependable service —on tiny pins—on mammoth ring gears —on thousands of other parts. Investigate the Lindberg Induction Heating Units— you will profit from their toughness... their ability to deliver 24 hour a day operation —day after day. Ask for Bulletin 1440.

LINDBERG *HIGH FREQUENCY DIVISION*

Lindberg Engineering Company, 2466 W. Hubbard Street, Chicago 12, Illinois

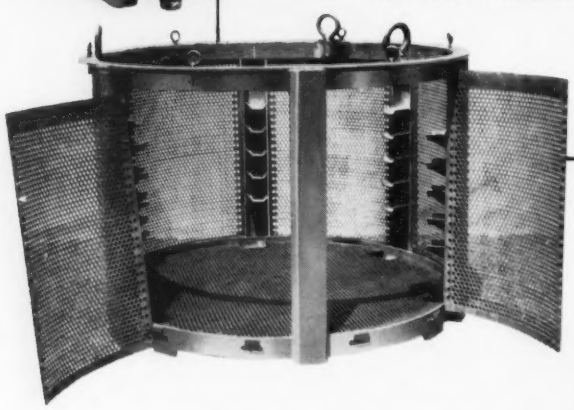


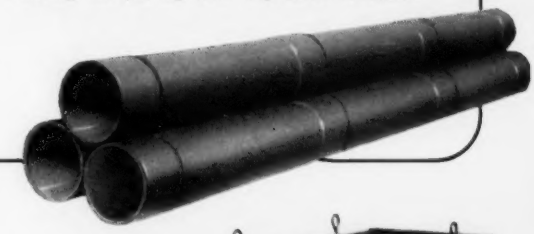
Cut Manual Handling Time

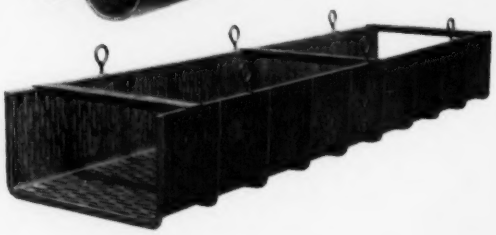
WITH *Light Weight* PSC ANNEALING CONTAINERS

Because they weigh up to 2/3 less than cast containers, PSC welded alloy annealing units obviously handle much easier and faster. Let us show you how installations are effecting impressive savings in labor costs alone.

Left top, light-weight box with sand seal construction for bright annealing.
Left bottom, special basket for aircraft parts; movable sides and trays.
Right top, annealing tubes for steel mills. Only ¼" alloy; years of service.
Right bottom, combination annealing and pickling rack. Top braces removable.







In addition to the savings in handling time, PSC light-weight annealing containers effect four other substantial economies. First, being so much lighter in weight, they attain pot heat in less time; PSC installations have shortened heating cycles as much as 5 hours. Second, fuel savings; a recent study showed a $40 saving per anneal. Third, being less bulky, PSC units increase furnace capacity. Fourth, their much longer service life cuts replacement costs.

The PRESSED STEEL PSC

Standard and Special Types for Every Purpose

PSC welded alloy heat-treating equipment is furnished in any size, design or metal specification: annealing and carburizing boxes, covers, baskets, racks, tubes, retorts, etc. As a pioneer of welded alloy units, we offer a wealth of experienced engineering assistance. Send blue prints or write as to your needs.

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆